Docket No. 741124-79

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)
Michael HERMANN	) Group Art Unit: 2872
Application No.: 09/817,797	) Examiner: Audrey Y. Chang
Filed: March 27, 2001	) Confirmation No. 8356
For: DEVICE FOR QUANTITATIVE ASSESSMENT OF THE ALIGNED POSITION OF TWO MACHINE PARTS, WORKPIECES OR THE LIKE	)

APPEAL BRIEF

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 223 13-1450

Sir:

This appeal brief is presented in furtherance of the Notice of Appeal filed June 17, 2009, in connection with the above-identified application.

Real party in interest.

Prüftechnik Dieter Busch AG of Germany is the real party in interest.

Related appeals and interferences.

There are no related appeals or interferences. However, it is noted that, at the time of filing of this Brief, a petition is pending with respect to a new matter objection requiring deletion of subject matter from the claims currently on appeal and as set forth in the *Claims appendix*.

Status of Claims.

Claims 1, 3 & 4 stand rejected and constitute the subject matter of this appeal. Claim 2 has been cancelled. No other claims exist.

Status of Amendments.

No amendment was filed subsequent to final rejection being appealed.

Summary of claimed subject matter.

Inasmuch as claims 1, 3 & 4 are similar in many respects and there patentability is argued jointly below, a consolidated summary of the claimed subject matter is presented below with only key differences of claim 3 being indicated.

A device for measuring or evaluating the relative angular offset position of two elements with respect to each other (Fig. 3), comprising a collimated light source 20 for producing at least one light beam (25) is connected to a first of the two elements at a known location (jz~aragraph [0018], second sentence, page *5)* and a first two-dimensionally readable optoelectronic sensor (110) and at least one second two-dimensionally readable optoelectronic sensor (120) connected to a second of the two elements, each of which is in a fixed relative alignment with respect to each other (paragraph [0018], third sentence, page *5)* at a known location such that a portion of the at least one light beam (25) is incident on a surface of an optoelectronically active layer of the first optoelectronic sensor (110, paragraph [0018], last sentence, page *5)* and is reflected by the surface of the optoelectronically active layer as a light beam *(125)* directly onto a surface of the at least one second two -dimensionally readable optoelectronic sensor (120, Fig. 3). An electronic means for receiving output signals from each of the optoelectronic sensors representing the coordinates at which the at least one light beam and reflected portion of the at least one light beam are detected on each respective sensor of the optoelectronic sensors, processing the signals, and computing the relative angular offset position of the two elements with respect to each other based on the coordinates detected (paragraph [0019], spanning pages *5* & 6). In alternative embodiments to which claim 3 is directed, a portion of the light beam incident on the first two-dimensionally readable optoelectronic sensor is reflected as a plurality of light beams (125, 225, 325; Fig. 4) in a folded beam path (125, 125'; Fig. *5* modification of Fig. 4) by a surface of an optoelectronically active layer of the first optoelectronic sensor (110)

directly onto the second two-dimensionally readable optoelectronic sensor (see paragraphs [0021] and [0022], page 6).

Grounds of rejection to be reviewed on appeal.

Whether claims 1, 3 and 4 are unpatentable under *35* U.S.C. § 112, first paragraph as failing to meet the written description requirement.

Whether claims 1, 3 and 4 are unpatentable under 35 U.S.C. § 112, first paragraph as being based on a non-enabling disclosure.

Whether claims 1, 3 and 4 are unpatentable for indefiniteness under 35 U.S.C. § 112, second paragraph.

Whether claims 1, 3 and 4 are unpatentable under 35 U.S.C. § 103(a) over the Holzl '998 patent when viewed in conjunction with applicant's admitted prior art.

Argument.

Rejection of claims 1, 3 and 4 as being unpatentable under 35 U.S.C. ~ 112, first paragraph as failing to meet the written description requirement.

As noted by the Examiner, to satisfy the written description requirement, a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention. It has been held that there is no *in haec verba* requirement for literal use of the claim language, and that it is sufficient that newly added claim limitations be supported in the specification through express, implicit, or inherent disclosure. Furthermore, it is stated in MPEP § 2163.04that:

> A description as filed is presumed to be adequate, unless or until sufficient evidence or reasoning to the contrary has been presented by the examiner to rebut the presumption. See, e.g., *In re Marzocchi,* 439 F.2d 220, 224, 169 USPQ 367, 370 (CCPA 1971). The examiner, therefore, must have a reasonable basis to challenge the adequacy of the written description. The examiner has the initial burden of presenting by a preponderance of evidence why a person skilled in the art would not recognize in an applicant's disclosure a description of the invention defined by the claims. *Wertheim,* 541 F.2d at 263, 191 USPQ at 97.

I. STATEMENT OF REJECTION REQUIRE-MENTS

In rejecting a claim, the examiner must set forth express findings of fact regarding the above analysis which support the lack of written description conclusion. These findings should:

(A) Identify the claim limitation at issue; and

(B) Establish a prima *facie* case by providing reasons why a person skilled in the art at the time the application was filed would not have recognized that the inventor was in possession of the invention as claimed in view of the disclosure of the application as filed. A general allegation of "unpredictability in the art" is not a sufficient reason to support a rejection for lack of adequate written description.

In the present case, the Examiner has failed to establish facts that demonstrate the specification does not describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention without any explanation of the type required as to why that is the case.

On the other hand, applicant has submitted a Declaration of Roland Hölzl (hereafter, the "Hölzl Declaration"), the inventor of the U.S. Patent No. 5,026,998 which the Examiner relied upon in her rejections under § 103 which provides factual evidence that directly refutes the assumptions and conclusions expressed by the Examiner. The first paragraph of section 4 of the Declaration contains a statement by one of ordinary skill in that art that the specification "reflects the fact that The Inventor was in possession of the invention recited in The Claims," and then, in the following paragraphs of that section explains in detail why such is the case. As noted by the Court in its decision in *In re Lange,* 644 F.2d 856 (CCPA 1981), 209 USPQ 288 "The disclosure in question must be read in light of the knowledge possessed by those skilled in the art, and knowledge can be established by affidavits of fact composed by an expert." Thus, applicant having established the knowledge of those skilled in the art by expert declaration, in the absence of facts which rebut those established by the declarant, not merely the examiner's personal opinions, the rejection based upon the written description requirement must be reversed.

<u>Rejection of claims 1, 3 and 4 as being unpatentable under 35 U.S.C. § 112, first paragraph as being based on a non-enabling disclosure</u>.

The same section 4 of the Hölz Declaration referred to above also clearly establishes that one of ordinary skill in the art would know how to make and use the invention, both with respect to the known location recitations and how to measure and evaluate the relative position of two elements with respect to each other. As pointed out in MPEP § 2164.05, a "<u>declaration or affidavit is, itself, evidence that must be considered</u> The examiner should **<u>never</u>** make the

determination based on personal opinion" (emphasis in original). Still further, MPEP § 21604.08 points out that the Federal Circuit has held that"[a]ll that is necessary is that one skilled in the art be able to practice the claimed invention, given the level of knowledge and skill in the art. Further the scope of enablement must only bear a "reasonable correlation" to the scope of the claims. See, e.g., *In re Fisher,* 427 F.2d 833, 839, 166 USPQ 18, 24 (CCPA 1970)."

Here, the declarant has explained why/how one of ordinary skill in art would be able to practice the claimed invention given the disclosure of the Lysen patent (USP 6,337,742), the fact that "the primary difference between the device described in the present application and that described in the Lysen Patent is that the beam splitter 22 of the Lysen Patent is eliminated and the reflectivity of sensor 110 of the Hermann Application is utilized instead," and that the reference in paragraph [0026] of the specification to the fact that the invention "is 'especially suited' for use in the position detection system of "German Patent Application DE 19733919 and U.S. Patent 6,049,378" (which the Examiner evidently does not contend is invalid for lack of an enabling disclosure) and is a clear disclosure that the techniques for measuring or evaluating the relative position of two elements with respect to each other of the Lysen Patent apply to the invention of the present application.

The Examiner's comments indicate that her rejection is based on a failure to "explicitly" provide support for the claimed subject matter, but no such requirement exists in the law. To the contrary, specifications are written to the level of ordinary skill in the art. Thus, the Examiner's reference, in item (2) spanning pages 3 and 4 of the March 2009 final rejection, to those items which are not mentioned in the specification is irrelevant given that the declarant Hözl has stated these factors to be among those items known to one of ordinary skill. The Examiner lacks the authority to simply refute factual evidence without demonstrating that the facts are incorrect and are outside of what was known in the art.

Accordingly, the rejection of claims 1, 3 and 4 as being unpatentable under 35 U.S.C. § 112, first paragraph as being based on a non-enabling disclosure is not sustainable and should be reversed.

<u>Rejection of claims 1, 3 & 4 for indefiniteness under 35 USC § 112, second paragraph</u>

The claims have also been rejected as being confusing and indefinite. The Examiner has stated "the phrases 'known location', is confusing and indefinite since it is not clear with respect to what are these known locations." To support her position, the Examiner has merely conjectured reasons why one might find the claims indefinite with reference to the possibility of different coordinate systems being used, but provides no evidence which would indicate that such views would be consider problems by one working in this field. On the other hand, the Declarant Hölz explains in detail in paragraph 4 of his declaration why "the 'known location' recitation found in claims 1 & 3 would be found to be clear and definite by one of ordinary skill

in the art" for specific reasons. The Examiner's position is tantamount to saying that, if one puts something in a specific spot, that person would not know its location. Furthermore, contrary to the Examiner's position, the coordinate system used to identify the "known" location is irrelevant, as is whether multiple coordinate systems are used since known techniques exist for converting from one coordinate system to another, e.g., geodedic to XYZ, and in fact, commercial software programs are readily available that can convert and transform spatial data between any of the hundreds of known coordinate systems, a fact that the Examiner has not asserted is incorrect.

Thus, it is submitted that the appealed claims are clear and definite, so the rejection for being "confusing and indefinite" should be withdrawn.

Rejection of claims 1, 3 and 4 as being unpatentable under 35 U.S.C. § 103(a) over the Holzl '998 patent when viewed in conjunction with applicant's admitted prior art (AAPA).

In response to the Examiner's rejection, applicant submitted the above mentioned Hölzl Declaration after having previously submitted a declaration of Heinz P. Bloch (hereafter, the Bloch Declaration), As also noted above, the declarant Hölz is the inventor of the U.S. Patent No. 5,026,998 which the Examiner has relied upon in her rejections under § 103. This Declaration provides factual evidence that directly refutes the assumptions and conclusions that have been expressed by the Examiner and explains why the invention is not obvious in view of his patent and the acknowledged commercially available optoelectronic sensors (see, paragraphs 3 & *5* of the Hölz Declaration). Similarly, paragraphs 3-7 of the Bloch Declaration also explain why it was not obvious to use the reflectivity of the known sensors, and in particular, why it would not be obvious to use their reflectivity to modify the device of the Hölz patent.

In the face of such evidence from the inventor of the patent upon which she relies and from an independent, accomplished engineer and inventor working in the relevant field, it is improper from the Examiner to rely solely upon her personal opinion as to what one of ordinary skill in the art would have found to be obvious without providing any factual evidence to support her positions. That is, declaration evidence provided clearly and unequivocally establishes that the invention would not have been obvious from anything taught that is taught by the applied prior art even when considered in combination with that which was known to those of ordinary skill in the art. For example, paragraph nos. 3 & *5*, on pages 2 & 5 of the Hözl Declaration, repectively, state in part:

> ... at that the time of that the Hermann Application was filed, I and others in the field considered the reflectivity of the sensors to be a problem which had to be minimized or eliminated, for example, by blackening internal surfaces to avoid stray reflections, etc. and I know of no one that considered the reflectivity of the

optoelectronic sensors to be a usable feature prior to that discovery by Mr. Michael Hermann, the inventor of the Hermann Application (hereafter, "The Inventor").

... there is simply no basis for the Examiner's conclusion that it would have been obvious to use the reflective properties of the commercially available optoelectronic sensors in the manner taught by the Hermann Patent Application and in the manner set forth in The Claims. Likewise, while the operation principles of the device of the Hermann Patent Application are the same as in the Lysen Patent (not the device of My Patent which does and cannot use a housing in which first and second two-dimensionally readable optoelectronic sensors are fixed), there is simply no factual basis for the Examiner's conclusion that it would be "an obvious matter of design choice" to make the ***structural*** changes necessary to go from the device of the Lysen Patent to that of the Hermann Patent Application while retaining the same basic function, let alone to do so going from the very different method and apparatus of My Patent to that of the Hermann Application.

Likewise, paragraphs 4-7 of the Bloch Declaration state in part:

... the specification of the Hermann Application referred to by the Examiner merely indicates the existence of commercially available optoelectronic sensors that can be used in the practice of the invention of the Hermann Application. However, I find nothing in that description which would suggest knowledge of this fact by anyone other than the inventor of the Hermann Application. Furthermore, based on my knowledge and experience, the reflectivity of such sensors was never used for alignment determination purposes prior to the invention of the Hermann Application, nor was it recognized that the reflectivity of such sensors was sufficient for that purpose. To the contrary, the reflectivity of such sensors was generally treated as a characteristic which needed to be suppressed for alignment purposes by the use of an anti-reflectivity coating.

5. The Examiner's comments appear not to take into consideration either the lack of known reason to use the reflectivity of known optoelectronic sensors in an alignment device or the factors that would necessarily have to have been recognized for someone to consider such use of the known optoelectronic sensors....

.... Without a reason or motivation for making such wholesale changes (which I find to be totally absent from the Hölzl Patent, the Examiner's reasoning, and the state of the art as I am aware of it), it is simply not reasonable to think that those

> working in the field would find it obvious to change from an established practice to one that had never been previously considered.
>
> ... the evidence indicates that one of ordinary skill in the art would not have been able to arrive at a device having the features of the claims of the Hermann Application based on anything objectively derivable from the Hölzl Patent, and the mere existence of commercially available optoelectronic sensors that could be used to practice the invention of the Hermann Patent.

Not only is the Examiner's conclusions of obviousness erroneous and contrary to facts established by declaration, but they have been arrived at using an improper "obvious matter of design choice" standard of obviousness that is contrary to the law as stated by both the Board of Appeals in the case of *Ex Parte Gerlach and Werner*, 212 USPQ 471, (1980) which states that:

> There is nothing in the statutes or the case law which makes 'that which is within the capabilities of one skilled in the art' synonymous with obviousness.
>
> The examiner provides no reason why, absent the instant disclosure, one of ordinary skill in the art would be motivated to change [the structure of the references to that which was claimed].

and the Federal Circuit which has stated that the mere fact that a modification could be made does not make it obvious absent a teaching of desireability; see, *In re Deminski*, 796 F.2d 436, 230 USPQ 313 (Fed. Cir. 1986) and *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984). In the present case, not only has the Examiner failed to provide the requisite reason or motivation for what she contends to be obvious, but she also does not even attemptto determine what changes would be needed since more than a mere change of one sensor for another is required. Thus, the Examiner has not made the factual determinations set forth in *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 48 (Supreme Court 1966), which include providing reasons why one having ordinary skill in the art would have been led to modify the prior art or to combine prior art references to arrive at the claimed invention based upon some teaching, suggestion or inference in the prior art, *Uniroyal, Inc. v. Rudkin-Wiley*, 5 USPQ2d 1434 (Fed. Cir. 1988). The statement that something is an "obvious design choice" is a mere conclusion for which some factual evidence in the prior art must be established, something the examiner has wholly failed to do and something that the Declaration emphatically refutes.

Instead of performing a proper assessment of the obviousness of the claimed invention, the examiner has attempted to attack the declaration evidence on the basis that it does not describe the construction of the sensors and because the declarant is not an inventor of sensors having a reflective surface (see, section 1, paragraph (1), page 2 of the final office action), neither of which is relevant. That is, since the sensors of the invention are of conventional construction and it is the use, not the manufacture of such sensors to which the invention relates,

what is material is that the declarant is knowledgeable of the reflective nature of such sensors and the manner in which they have been used, which is the case for both declarants.

Furthermore, rather than address the reasons that the declarants have found the invention to be unobvious, for example, the examiner has failed to indicated where it is taught or suggested by the AAPA (or Hölzl) that the reflective capabilities of the surface of a first optoelectronic sensor can be utilized in a two-sensor position determination system, when the declarants state that such was unknown at the time that the present invention was made, the Examiner has essentially taken the position that as long as the operational principle remains the same, it would be obvious to convert a transmissive system to reflective system, irrespective of what structural changes might be necessary to do so (see, the paragraph spanning pages 10 & 11 of the March 2009, final office action). However, it is incumbent upon the examiner, in the face of the declaration evidence submitted, to provide some evidence which refutes the declaration statements and demonstrates that someone other than this applicant recognized that the reflectance possessed by the known optoelectronic sensors was anything other than a detriment and could be used to provide accurate position determinations in combination with a second optoelectronic sensor in the manner of the present invention, which she has not done. In this regard, applicant submitted to the examiner evidence of the results of a search of the USPTO patent database that revealed more than 1000 patents which disclose anti-reflectance coatings for optoelectronic sensors, clearly supporting the declarants' views that one of ordinary skill in the art considered the reflective characteristics of the surface of an optoelectronic sensor to be an undesirable feature as evidenced by the common use of anti-reflection coatings on such sensors. On the other hand, the Examiner has been unable to cite even one patent or publication in which the reflectance of an optoelectronic sensor was used in a manner even remotely comparable to that of the present invention, nor have any trends in the industry or any other factors been demonstrated that would have lead someone of ordinary skill to claimed invention.

Furthermore, the examiner has made no attempt to refute the evidence provided which also included the fact that the inventors of the devices of the referenced U.S. Patents 6,337,742 and 6,476,914 (cited in paragraph [0002] of the specification and applicant's Amendment After RCE filed August 30, 2005 and the German counterparts of which were filed with an Information Disclosure Statement and considered by the Examiner in her Action of August 2004), which are more recent than that of the Hölz patent relied upon by the examiner, found it necessary to use mirrors and a prism instead of the reflective capacity of the sensors. Such facts further indicate that the potential usefulness of the reflective properties of known sensors was not recognized by those of ordinary skill and so that their reflective properties need not be counteracted. In this regard, it is pointed out that the Federal Circuit has held that proceeding contrary to accepted wisdom in the art is evidence of nonobviousness. *In re Hedges,* 783 F.2d 1038, 228 USPQ *685* (1986).

Therefore, in light of the deficiencies in the Examiner's assessment commented upon above, even if an initial *prima facie* case of obviousness had been established by the proposed combination of the teachings of Holzl and AAPA, it has been overwhelmingly rebutted so that the burden of proof shifted back to the Examiner to provide factual evidence, not her own opinions, which would support a conclusion of obviousness despite the evidence submitted by applicant, something that has not even been attempted by the examiner. Consequently, the rejection of claims 1, 3 and 4, under § 103(a), is improper and should now be reversed.

Conclusion

All of the examiner's rejections have been demonstrated to be improper and contrary to established facts. Therefore, the Board is requested to reverse all of the appealed rejections.

Accompanying this Brief is payment of the Appeal Brief fee of $ *255.00,* and any overage or shortage thereof may be charged or credit to Deposit Account No. 50-2478(741124-79).

Respectfully submitted,

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Claims appendix.

1. (Previously Presented) Device for measuring or evaluating the relative angular offset position of two elements with respect to each other, comprising:

- a collimated light source means for producing at least one light beam connected to a first of the two elements at a known location;

- a first two-dimensionally readable optoelectronic sensor and at least one second two-dimensionally readable optoelectronic sensor connected to a second of the two elements each of which are in a fixed relative alignment with respect to each other at a known location such that a portion of said at least one light beam incident on a surface of an optoelectronically active layer of the first optoelectronic sensor is reflected by the surface of the optoelectronically active layer as a light beam directly onto a surface of the at least one second two-dimensionally readable optoelectronic sensor;

- electronic means for receiving output signals from each of the optoelectronic sensors representing the coordinates at which the at least one light beam and reflected portion of the at least one light beam are detected on each respective sensor of the optoelectronic sensors, processing the signals, and computing the relative angular offset position of the two elements with respect to each other based on the coordinates detected.

3. (Previously Presented) Device for measuring or evaluating the relative angular offset position of two elements with respect to each other, comprising:

- a collimated light source for producing at least one light beam connected to a first of the two elements at a known location;

- a first two-dimensionally readable optoelectronic sensor and at least one second two-dimensionally readable optoelectronic sensor;

- a housing, connected to a second of the two elements at a known location, in which the first and second two-dimensionally readable optoelectronic sensors are positioned relative to one another at a known location with respect to said housing such that a portion of the light beam

incident on the first two-dimensionally readable optoelectronic sensor is reflected as a plurality of light beams in a folded beam path by a surface of an optoelectronically active layer of the first optoelectronic sensor directly onto the second two-dimensionally readable optoelectronic sensor;

- electronic means for receiving output signals from the optoelectronic sensors, processing the signals representing the coordinates at which the at least one light beam and reflected portion of the at least one light beam are detected on each respective sensor of the optoelectronic sensors, and computing the relative angular offset position of the housing relative to the light source based on the coordinates of incidences of the at least one light beam on the surfaces of the two-dimensionally readable optoelectronic sensors detected.

4. (Previously Presented) Device for measuring or evaluating the relative and angular offset position of two elements with respect to each other, comprising:

- a collimated light source means for producing at least one light beam at a known coordinate location;

- a first two-dimensionally readable optoelectronic sensor;

- at least one second two-dimensionally readable optoelectronic sensor in a fixed relative alignment with respect to the first two-dimensionally readable optoelectronic sensor at a known location such that the at least one light beam from the light source means is incident on a surface of an optoelectronically active layer of the first two-dimensionally readable optoelectronic sensor and a portion of the at least one light beam is reflected by the surface of the optoelectronically active layer as at least one light beam directly onto a surface of the at least one second two-dimensionally readable optoelectronic sensor;

- electronic means for receiving output signals from each of the optoelectronic sensors, processing the signals representing the coordinates at which the at least one light beam and reflected portion of the at least one light beam are detected on each respective sensor of the optoelectronic sensors, and computing the relative angular offset position of the light source means relative to the incidences of the at least one light beam on the surfaces of the two-dimensionally readable optoelectronic sensors.

Evidence appendix.

1. Declaration of Roland Hölz filed April 17, 2007 and considered by the examiner in her Office Action of June 15, 2007.

2. Declaration of Heinz P. Bloch filed January 7, 2005 and considered by the examiner in her Office Action of March 30, 2005.

3. USPTO patent database printout submitted with applicant's amendment filed December 1, 2003, neither addressed nor refused entry by examiner in following Office Actions.

4. U.S. Patent 6,337,742

5. U.S. Patent 6,476,914

Related proceedings appendix.

None.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)
Michael HERMANN	) Group Art Unit: 2872
Application No.: 09/817,797	) Examiner: A. Y. Chang
Filed: March 27, 2001	) Confirmation No. 8356
For: DEVICE FOR QUANTITATIVE ASSESSMENT OF THE ALIGNED POSITION OF TWO MACHINE PARTS, WORKPIECES OR THE LIKE	)

DECLARATION OF ROLAND HÖLZL

I, Roland Hölzl, declare that:

1. I am the same Roland Hölzl that is the inventor of the shaft alignment checking method of U.S. Patent No. 5,026,998 (hereafter, "My Patent"), and am an inventor or co-inventor of the inventions of U.S. Patent Nos. 6,566,871; 6,515,294; 6,476,914; 6,146,000; 5,049,757, and others.

2. I have reviewed a copy of United States Patent Application Publication US 2001/0052983 A1, which I understand corresponds to the above-identified U.S. Patent Application (hereafter, the "Hermann Application") as originally filed. I have reviewed the attached Amendment After Second RCE which I understand contains the claims that presently exist in the application (hereafter, "The Claims") and the appended communication from the Examiner dated November 7, 2006 (hereafter, the "Office Action"). I also have reviewed Lysen et al. U.S. Patent No. 6,337,742 (hereafter, the Lysen Patent) which is the U.S. counterpart of the German Patent

Application DE 38 14 466 that is described in paragraphs [0003] and [0004] of the Hermann Application.

3. Based on my knowledge and experience, those of ordinary skill in the art did not know that the reflectivity of the surface of sensors that were commercially available prior to the March 27, 2001, filing date of the Hermann Application was sufficient to enable them to be usable as either the mirror surfaces 6a of My Patent or in the manner in which the reflectivity of the sensors 110, 120 is used as is described in Hermann Application. To the contrary, at that the time of that the Hermann Application was filed, I and others in the field considered the reflectivity of the sensors to be a problem which had to be minimized or eliminated, for example, by blackening internal surfaces to avoid stray reflections, etc. and I know of no one that considered the reflectivity of the optoelectronic sensors to be a usable feature prior to that discovery by Mr. Michael Hermann, the inventor of the Hermann Application (hereafter, "The Inventor").

4. Based on my knowledge and experience, the statements contained in items 6 & 8-10 of the Office Action, incorrectly reflect the knowledge of one of ordinary skill in the alignment art. Furthermore, based on my knowledge and experience in the alignment art, the Hermann Application adequately discloses how to make and used the invention defined by The Claims and reflects the fact that The Inventor was in possession of the invention recited in The Claims, with respect to which the "known location" recitation found in claims 1& 3 would be found to be clear and definite by one of ordinary skill in the art as explained further below.

Considering first the "known location" language, it is known to me that it has been standard practice in the shaft alignment field to first determine the distance of a least one of the sensors on one of the shafts from the laser beam on the other of the shafts, e.g., a tape measure, and for this reason all suppliers of alignment devices ship their products with a tape measure and have been doing so for decades, and as stated in the last paragraph of column 4 of the Lysen Patent, "the distance of the position detectors 23 and 25 from the radiation source S is obtained in any manner independently of the measuring device." Furthermore, it would have been apparent to one of ordinary skill in the alignment art that the primary difference between the device described in the Hermann Application and that described in the Lysen Patent is that the beam splitter 22 of the Lysen Patent is eliminated and the reflectivity of sensor 110 of the Hermann Application is utilized instead, so that all of basic comments contained therein, including those in the first paragraph of column 5 with regard to how "the knowledge of this distance [i.e., the distance between the light source S and the detectors 23 or 25] needed for the calculation can be obtained," would have been recognized to apply to the invention recited in The Claims. Thus, one of ordinary skill in the art would not be confused by this recitation and would know that the recitations of "a collimated light source ...connected to a first of the two elements at a known location" and "a housing, connected to a second of the two elements at a known location" is referring to this standard practice of determining the distance between the light source and the sensor unit and would know multiple ways of doing so.

Likewise, the recitation that "the first and second two-dimensionally readable optoelectronic sensors are positioned relative to one another at a known location with respect to said housing" would have been recognized as a basic requirement of the device disclosed in the Hermann Patent Application. As noted in the Lysen Patent (see, e.g., second full paragraph of column 3), the position sensors must be aligned in the direction of projection of the beam from the light source, and since the sensors 110, 120 of the Hermann Patent Application are enclosed with the housing 500, this cannot be done without knowing the positional relationship between the housing and the sensors in it. In the design phase of the Hermann device the relative positions of the sensors with respect to the housing and the laser beam are directly determined. Furthermore, that the position of these sensors is known is readily apparent from the reference to the sensor location coordinates IC1; A and IC1; B in paragraph [0017] of the Hermann Patent Application.

Moreover, the statement in paragraph [0026] to the effect that the device of the Hermann Application has is "especially suited" for use in the position detection system of "German Patent Application DE 19733919 and U.S. Patent 6,049,378" is a clear disclosure that techniques for measuring or evaluating the relative position of two elements with respect to each other of the Lysen Patent apply to the invention of the Hermann Application.

5. With regard to the Examiner's positions stated in paragraph 12 of the Office Action, based on my knowledged and experience, the conclusions stated in that paragraph are not supported by the facts as they exist. First, based upon the facts set forth above in paragraph 3 of this Declaration, there is simply no basis for the Examiner's conclusion that it would have been obvious to use the reflective properties of the commercially available optoelectronic sensors in the manner taught by the Hermann Patent Application and in the manner set forth in The Claims. Likewise, while the operation principles of the device of the Hermann Patent Application are the same as in the Lysen Patent (not the device of My Patent which does and cannot use a a housing in which first and second two-dimensionally readable optoelectronic sensors are fixed), there is simply no factual basis for the Examiner's conclusion that it would be "an obvious matter of design choice" to make the ***structural*** changes necessary to go from the device of the Lysen Patent to that of the Hermann Patent Application while retaining the same basic function, let alone to do so going from the very different method and apparatus of My Patent to that of the Hermann Application.

6. All statements made herein of my/own knowledge are true, all statements made herein on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

April 11, 2007

R. Hölzl
Roland Hölzl

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Docket No. 741124-79

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	) **RESPONSE UNDER 37 CFR**
Michael HERMANN	: **1.116 EXPEDITED PROCEDURE**) **EXAMINING GROUP 2872**
Application No.: 09/817,797	) Examiner: A. V. Chang
Filed: March 27, 2001	) Confirmation No. 8356
For: DEVICE FOR QUANTITATIVE ASSESSMENT OF THE ALIGNED POSITION OF TWO MACHINE PARTS, WORKPIECES OR THE LIKE	)

CERTIFICATE OF TRANSMISSION

I hereby certify that this correspondence is being facsimile transmitted to the United States Patent and Trademark Office: Fax No. (703) 872-9306 on January 7, 2005.

Kathleen M. McManus
Kathleen M. McManus

DECLARATION OF HEINZ P. BLOCH

I, Heinz P. Bloch, declare that:

1. I am the owner of Process Machinery Consulting Co., hold Bachelor and Masters of Science degrees in Mechanical Engineering, I am a licensed professional engineer in the states of Texas and New Jersey, I hold five U.S. Patents including U.S. Patent No. 4,102,052 for a "DEFLECTION INDICATOR FOR COUPLINGS" for use in monitoring and determining axial deflection or positioning of a coupling, I have authored or co-authored over 300 technical papers, I have received several awards as an engineer including the ASME/STS Engineer of the Year Award (1995) and ASME Distinguished Service Award (2001).

2. I have reviewed the above identified patent application (hereafter, the HERMANN Application) including its specification and claims, and the positions stated by the Examiner in support of her decisions indicating that the claims do not define patentable subject matter, and also U.S. Patent No. 5,026,998 (hereafter, the Hölzl Patent) and "admissions" which form the basis of the Examiner's positions.

3. I understand that a significant aspect of the definition of the invention recited in claims 1, 3 and 4 is that two-dimensionally readable optoelectronic sensors are used to determine the relative alignment of two elements with respect to each other by a portion of at least one light beam incident on a surface of an optoelectronically active layer of one of the optoelectronic sensors being reflected by its surface directly as a light beam onto a surface of another of the two-dimensionally readable optoelectronic sensors, an electronic means receiving output signals from each of the optoelectronic sensors, processing the signals, and computing the relative position of the light source means relative to the incidences of the light beam on the surfaces of the two-dimensionally readable optoelectronic sensors. In particular, I understand a key issue to be whether or not it would have been obvious to use the reflectivity of as a means for directing light from one optoelectronic sensor to another.

4. A review page 5, lines 14-20 of the specification of the Hermann Application referred to by the Examiner merely indicates the existence of commercially available optoelectronic sensors that can be used in the practice of the invention of the Hermann Application. However, I find nothing in that description which would suggest knowledge of this fact by anyone other than the inventor of the Hermann Application. Furthermore, based on my knowledge and experience, the reflectivity of such sensors was never used for alignment determination purposes prior to the invention of the Hermann Application, nor was it recognized that the reflectivity of such sensors was sufficient for that purpose. To the contrary, the reflectivity of such sensors was generally treated as a characteristic which needed to be suppressed for alignment purposes by the use of an anti-reflectivity coating.

5. The Examiner's comments appear not to take into consideration either the lack of known reason to use the reflectivity of known optoelectronic sensors in an

alignment device or the factors that would necessarily have to have been recognized for someone to consider such use of the known optoelectronic sensors. That is, it would have to have been recognized that the reflectivity of the known optoelectronic sensors as well as their sensitivity would have been suitable for a sufficiently strong light source to be aimed at the first sensor without damaging it and that a sufficient amount of light would be reflected as a beam (not as dispersed light) to be readable at the other sensor in a way that would provide sufficiently accurate results. Apart from the Hermann Application, e.g., paragraph [0007] on page 2, I know of no recognition of this fact by those working in the alignment field.

6. Furthermore, I can see no reason why anyone reviewing the Hölzl Patent would find it obvious to abandon his light transmissive arrangement and adopt the light reflective arrangement proposed in the Hermann Application. This is particularly the case because an entirely different positioning of the two sensors relative to each other and the light source would be required as can be appreciated from a comparison of Figs. 3 & 4 of the Hermann Application with Figs. 2 & 3 of the Hölzl Patent which, in turn, would require modification of the packaging of the components and how they would be usable on the shafts being aligned. Without a reason or motivation for making such wholesale changes (which I find to be totally absent from the Hölzl Patent, the Examiner's reasoning, and the state of the art as I am aware of it), it is simply not reasonable to think that those working in the field would find it obvious to change from an established practice to one that had never been previously considered.

7. Therefore, based on my experience in the field to which the invention of the Hermann Application is directed, and based on the facts noted above, the evidence indicates that one of ordinary skill in the art would not have been able to arrive at a device having the features of the claims of the Hermann Application based on

anything objectively derivable from the Hölzl Patent, and the mere existence of commercially available optoelectronic sensors that could be used to practice the invention of the Hermann Patent.

The undersigned Declarant declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Heinz P. Bloch

January 4, 2005
Date

Heinz P. Bloch, P.E.

Evidence appendix 3

USPTO PATENT FULL-TEXT AND IMAGE DATABASE

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Results of Search in 1976 to present db for:
((SPEC/(antireflection OR "anti-reflection coating") AND ((optical$ OR video) OR camera)) AND sensor$): 1012 patents.
*Hits **1** through **50** out of **1012***

Next 50 Hits

Jump To 400

Refine Search spec/(antireflection or "anti-reflection coating") and (o

	PAT. NO.	Title
1	6,650,916	T Method and apparatus for providing high contrast imaging
2	6,650,474	T Optical filter and optical device provided with this optical filter
3	6,650,455	T Photonic mems and structures
4	6,650,419	T Interferometric apparatus for precision measurement of altitude to a surface
5	6,649,951	T Light-receiving element and photoelectric conversion device
6	6,647,350	T Radiometric temperature measurement system
7	6,646,742	T Optical device and method for multi-angle laser light scatter
8	6,646,636	T Display system utilizing ambient light and a dedicated light source
9	6,643,024	T Apparatus and method(s) for reducing the effects of coherent artifacts in an interferometer
10	6,642,998	T Measuring device
11	6,642,994	T Optical exposure apparatus and photo-cleaning method
12	6,637,882	T Eye viewing device for retinal viewing through undilated pupil
13	6,636,678	T Method and apparatus for waveguide optics and devices
14	6,635,912	T CMOS image sensor and manufacturing method thereof
15	6,633,381	T Polychromatic fluorescence measurement device
16	6,631,004	T Single-pass and multi-pass interferometry systems having a dynamic beam-steering assembly for measuring distance, angle, and dispersion
17	6,628,432	T Image reader and image reading method
18	6,628,355	T Liquid crystal display panel including a light shielding film to control incident light

19 6,627,892 Infrared detector packaged with improved antireflection element
20 6,627,864 Thin image sensor package
21 6,626,532 Vari-focal spectacles
22 6,625,336 Optical sensor having dielectric film stack
23 6,621,584 Method and apparatus for in-situ monitoring of thickness during chemical-mechanical polishing
24 6,621,571 Method and apparatus for inspecting defects in a patterned specimen
25 6,621,561 Doppler rotational velocity sensor
26 6,621,557 Projection exposure apparatus and exposure methods
27 6,620,712 Defined sacrifical region via ion implantation for micro-opto-electro-mechanical system (MOEMS) applications
28 6,620,249 Method and apparatus for depositing thin layers
29 6,619,799 Optical lens system with electro-active lens having alterably different focal lengths
30 6,618,209 Optical apparatus
31 6,618,150 Compact transform spectrometer based on sampling a standing wave
32 6,618,141 Device for measurement of the spectral reflectance and process for measurement of the spectral reflectance
33 6,618,128 Optical speed sensing system
34 6,617,623 Multi-layered gate for a CMOS imager
35 6,614,827 High power laser
36 6,614,742 Optical head, magneto-optical head, disk apparatus and manufacturing method of optical head
37 6,611,546 Optical transmitter comprising a stepwise tunable laser
38 6,608,961 Optical system including a planar waveguide
39 6,608,847 Tunable laser with suppression of spontaneous emission
40 6,608,685 Tunable Fabry-Perot interferometer, and associated methods
41 6,608,677 Mini-lidar sensor for the remote stand-off sensing of chemical/biological substances and method for sensing same
42 6,608,671 Detector and screening device for ion channels
43 6,606,446 Miniature variable attenuator
44 6,606,340 Continuously grating-tuned external cavity laser with automatic suppression of source spontaneous emission and amplified spontaneous emission
45 6,606,171 Digitizing scanner
46 6,606,144 Projection exposure methods and apparatus, and projection optical systems
47 6,603,443 Compact display system controlled by eye position sensory system
48 6,597,449 Real time process control of optical components using linearly swept tunable laser
49 6,593,636 High speed silicon photodiodes and method of manufacture
50 6,593,213 Synthesis of layers, coatings or films using electrostatic fields

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US006337742B2

(12) **United States Patent**
Lysen et al.

(10) **Patent No.: US 6,337,742 B2**
(45) **Date of Patent: Jan. 8, 2002**

(54) **DEVICE FOR ASCERTAINING THE RELATIVE POSITION OF A REFERENCE AXIS OF AN OBJECT RELATIVE TO A REFERENCE BEAM, IN PARTICULAR A LASER BEAM**

(75) Inventors: **Heinrich Lysen**, München; **Dieter Busch**, Ismaning, both of (DE)

(73) Assignee: **Pruftechnik Dieter Busch AG**, Ismaning (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/840,168**

(22) Filed: **Apr. 24, 2001**

Related U.S. Application Data

(62) Division of application No. 07/455,354, filed as application No. PCT/EP89/00476 on Apr. 28, 1989, now abandoned.

(30) **Foreign Application Priority Data**

Apr. 28, 1988 (DE) 38 14 466

(51) **Int. Cl.**[7] **G01J 1/42**

(52) **U.S. Cl.** **356/614**; 356/3; 356/222; 250/208.2; 250/216

(58) **Field of Search** 365/3, 4.01, 614, 365/222; 250/208.2, 208.3, 216

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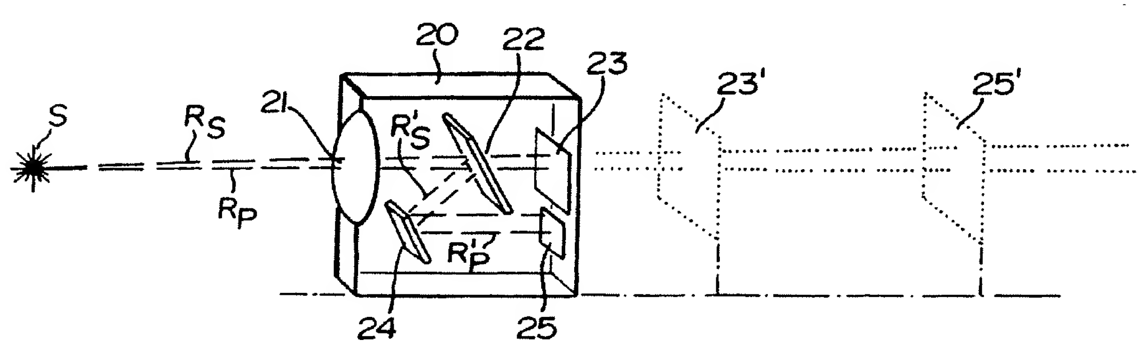
Primary Examiner—Frank G. Font
Assistant Examiner—Layla Lauchman
(74) *Attorney, Agent, or Firm*—Nixon Peabody LLP; David S. Safran

(57) **ABSTRACT**

A device is proposed, which makes it possible to ascertain the relative position of the reference axis BA of an object relative to a reference beam R_p of an electro-magnetic radiation, in particular a laser beam. The device displays a spatially fixed radiation transmitter S and at the object end a splitting mirror **22** as well as two position detectors **23** and **25**. The splitting mirror branches a partial beam R_p, off from the reference beam. The reference beam passing rectilinearly through the splitting mirror impinges on the one position detector and the partial beam on the other. The position detectors supply electrical signals, from which the position of the reference axis is ascertainable by means of a computer. The known devices of this species have an appreciable space requirement. This defect is eliminated by particular structuring of the beam conduction and the additional use of special optical means. Beyond that, the measurement possibilities can be enlarged through additional emission of a second reference beam R_s.

2 Claims, 3 Drawing Sheets



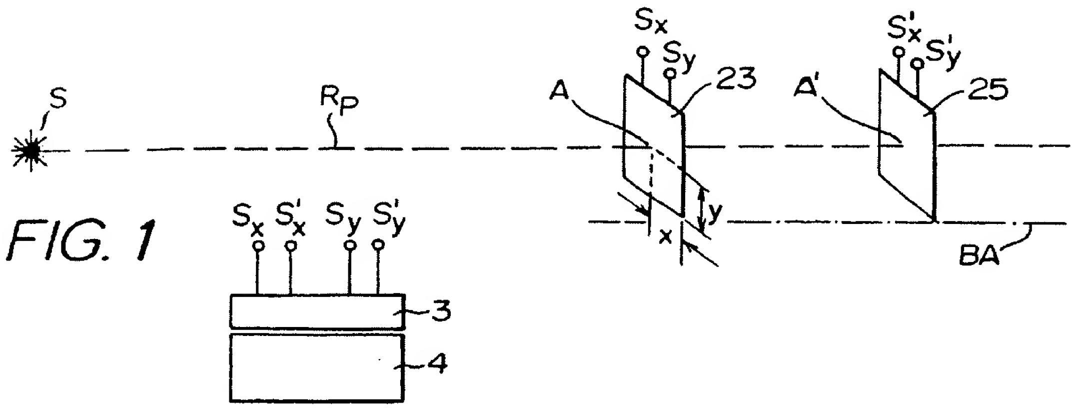


FIG. 1

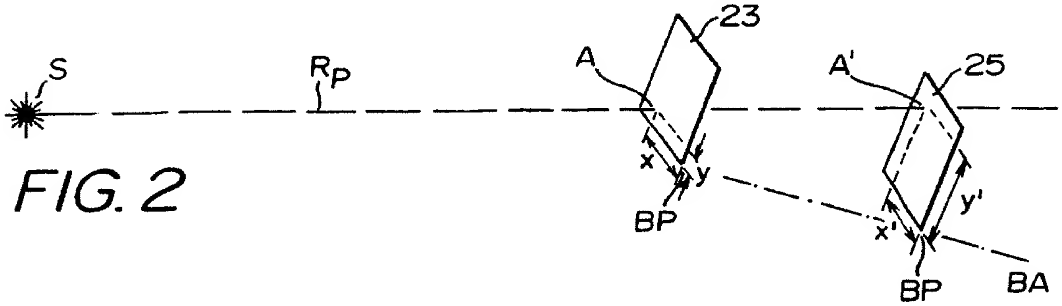


FIG. 2

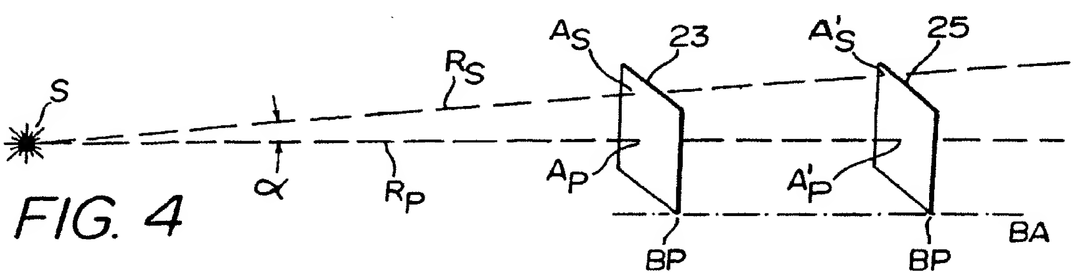


FIG. 4

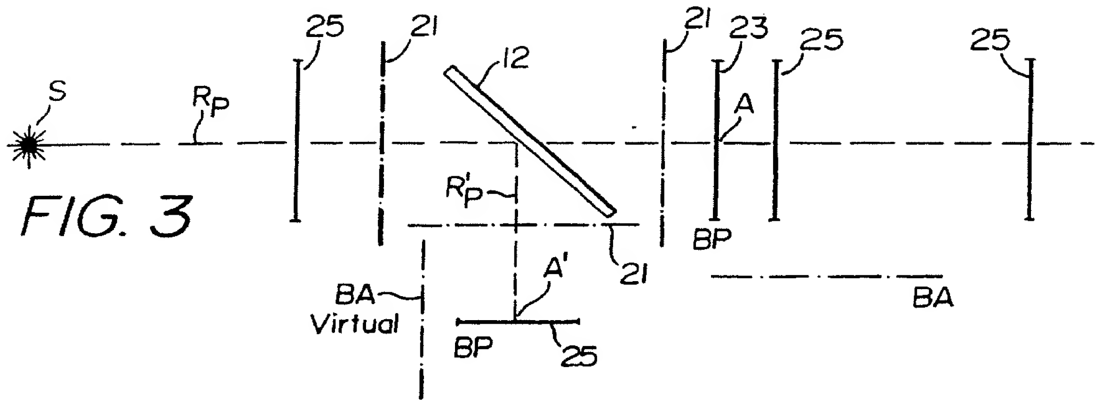


FIG. 3

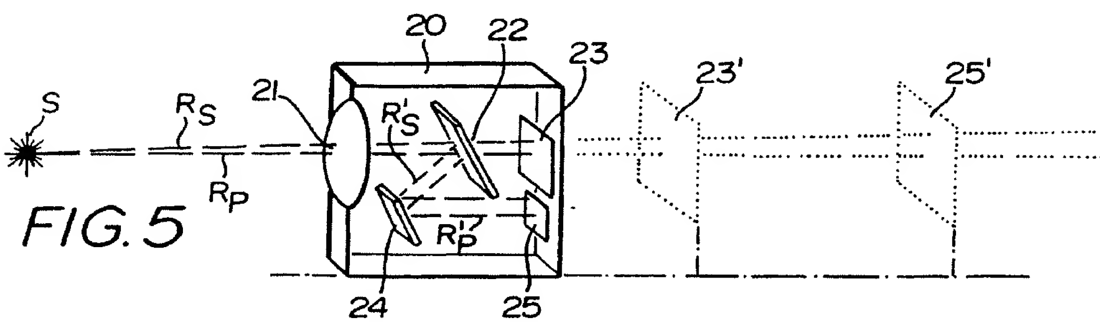


FIG. 5

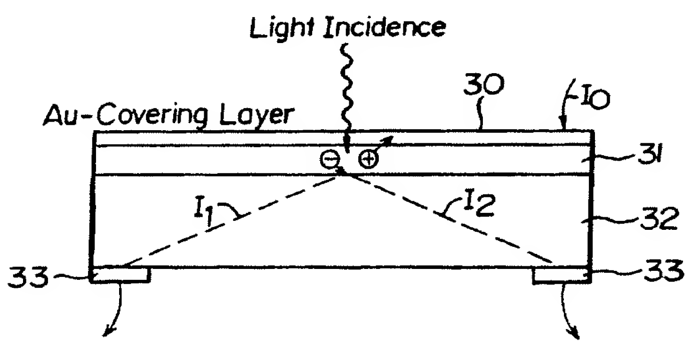


FIG. 6a

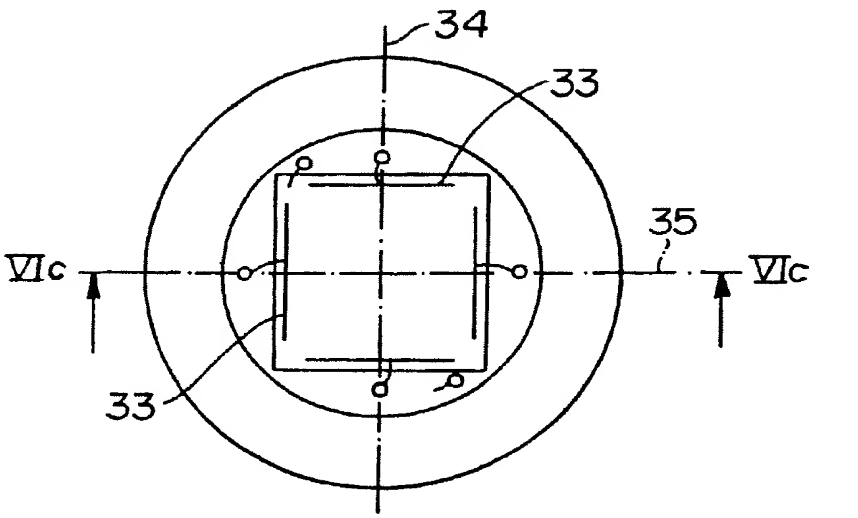


FIG. 6b

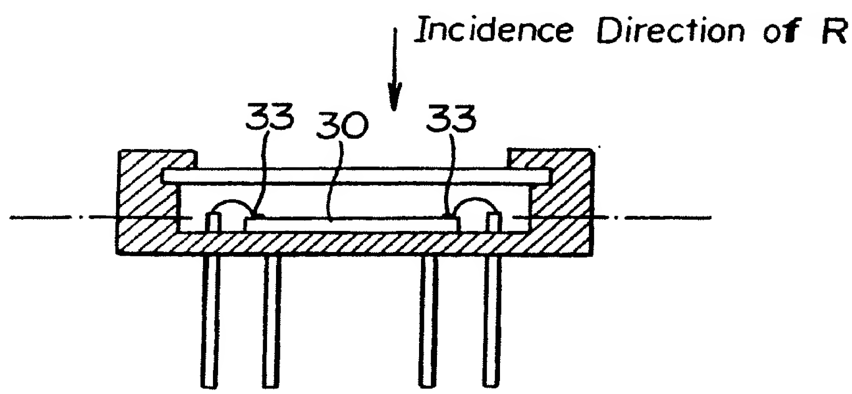


FIG. 6c

DEVICE FOR ASCERTAINING THE RELATIVE POSITION OF A REFERENCE AXIS OF AN OBJECT RELATIVE TO A REFERENCE BEAM, IN PARTICULAR A LASER BEAM

BACKGROUND OF THE INVENTION

This application is a Divisional of prior application Ser. No. 07/455,354, filed May 15, 1995 now abandoned, which is a 371 of PCT/EP89/00476, filed Apr. 28, 1989.

FIELD OF THE INVENTION

The present invention relates to a device for determining the relative position of a reference axis of an object with respect to a spatially fixed and substantially parallel focused reference beam of electromagnetic radiation, particularly a laser beam, directed thereto.

In the known devices of this kind, the partial beam is branched off at a right angle to the incident primary reference beam. In the known device, which is housed in the measuring head of an industrial robot for its laser-guided control (DE-A1 37 10 068), the position detector, onto which impinges the reference beam traversing the splitting mirror rectilinearly, serves the ascertaining of redispositions of the measuring head perpendicularly to the reference beam, whilst the other position detector, on which impinges the partial beam branched off at right angles, fulfills the purpose of delivering signals which are proportional to the rotation of the measuring head around the reference beam. An enlarging lens inserted into the beam path of the reference beam is so dimensioned that it effects an enlargement of the X direction and the Y direction on the first-mentioned position detector and the spacings of both the position detectors from the splitting mirror are arranged to be differently large, wherein the position detector hit by the reference beam is arranged near to the splitting mirror and the other position detector displays a substantially larger spacing herefrom perpendicularly to the reference beam. The consequence is that the known device displays a large space requirement in direction perpendicular to the laser beam.

The invention is based on the task of creating a device for determining the relative position of a reference axis of an object with respect to a spatially fixed and substantially parallel focused reference beam of electromagnetic radiation, particularly a laser beam, directed thereto, which has a substantially lower space requirement than the known devices and nevertheless displays a large effective length difference for the spacings between the measurement points on the measurement object so that it can be used with great resolving capability and great accuracy for the ascertaining of parallel displacements as well as also of angular displacements of the reference axis of the measurement object relative to the reference beam.

In the device according to the invention, an appreciably increased spacing is achieved geometrically between the measurement points at the object, namely the direct measurement point in the beam path of the reference beam and the virtual measurement point in the beam path of the partial beam, already with optimally small space requirement for the device due to the folding of the branched-off partial beam effected by the special kind of the twofold reflection of the same and this length difference is still enlarged optically by the dimensioning of the optical enlarging system especially adapted for this purpose.

A particularly compact and also interference-proof build-up of the device according to the invention is achieved by

the convergent optical system being arranged in front of the splitting mirror in the beam path of the reference beam and by the convergent optical system being cemented together with the splitting mirror and the deflecting mirror as well as with the position detectors into a compact optical glass system, for which purpose the convergent optical system for the optical enlargement of the measurement point spacing is installed in the beam path at the entry side of the compact optical glass system, thus already in front of the splitting mirror.

Rotations of the device about the axis of the reference beam as well as the spacing of the device from the radiation transmitter can be detected in the device according to the invention by the fact that the radiation transmitter emits two reference beams, which between them include an acute angle, towards the object that both impinge on the position detectors. The separation of both the penetration points of both the reference beams impinging on each detector can on appropriate choice of the position detectors be left to them. It is however particularly advantageous so to equip the radiation transmitter that it emits both the reference beams in alternation so that simpler biaxial position detectors can be used.

The invention is explained still more closely in the following by an example of embodiment with reference to the drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 to 3 schematic illustrations for explanation of the principle mode of operation of devices of the species forming the basis of the invention,

FIG. 4 a perspective illustration for the explanation of the principle, which is usable alternatively in the device according to the invention, of a measurement with two reference beams,

FIG. 5 in perspective illustration, a practical embodiment of the device according to the invention and

FIGS. *6a* to *6c* a constructional form of a position detector usable in the device according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

According to FIGS. 1 to 5, a spatially fixed radiation transmitter S emits a substantially parallelly focused primary reference beam R_p, preferably a laser beam, in such a direction that this impinges on two opto-electronic position detectors **23** and **25**, which are arranged either physically or virtually at a spacing one behind the other and reproduced schematically in the drawing by rectangles. The position detectors are rigidly fastened at an object which displays a fixed reference axis BA, the position of which relative to the primary reference beam R_p is to be ascertained in respect of parallel displacement and angular displacement and with the use of the two-beam principle according to FIG. 4—also in respect of its angular position around the primary reference beam R_p. The two-beam principle according to FIG. 4 moreover also still makes possible the ascertaining of the distance of the object from a fixed spatial point, for example the location of the radiation transmitter S.

The object, since its details do not matter, is represented in the drawing only by its reference axis BA.

The position detectors **23** and **25** are indicated schematically by rectangles in the drawing. They are represented physically one behind the other in FIGS. 1, 2 and 4 for the purpose of the explanation of the basic measurement prin-

ciple. In the practical embodiments of the devices according to the species, they are however in reality disposed only virtually one behind the other, but not physically, as is evident in principle from FIG. 3.

The position detectors **23** and **25** according to FIGS. **1** and **2** supply electrical signals which correspond to the magnitude and the sign of substantially mutually perpendicular coordinates x and y (detector **23**) or x' and y' (detector **25**), which are entered only in FIGS. **1** and **2**, of the spacing which the respective point of incidence A and A' of the primary reference beam R_p or a partial beam $R_{p'}$ (FIG. 3) branched off from this displays in the detector plane from a reference point BP in this. The position of the reference points BP in the detector plane is selectable arbitrarily according to practical measurement-technical premises, but fixed from the start and thus known. In the FIGS. **1** to **3** serving the explanation of the basic manner of function according to the species, the reference points BP each lie for the purpose of illustration at the lower front corner of the position detectors **23** and **25**, while their connecting line coincides with the reference axis BA fixed by the object.

The position detectors **23** and **25** are so arranged at the object displaying the reference axis BA that their co-ordinate axes are aligned in the direction of projection of the primary reference beam R_p.

In the position of the reference axis BA to be seen in FIG. **1**, the points of incidence A and A' of the primary reference beam R_p on the position detectors **23** and **25** have the same spacing in magnitude and direction from the respective reference point BP so that also the coordinate x corresponds to the co-ordinate x' and the co-ordinate y corresponds to the coordinate y' and the detectors supply corresponding signals S_x, $S_{x'}$, S_y and $S_{y'}$ by way of an appropriate signal converter **3** to the data processing equipment, for example, in the form of a commercially usual computer. From the signals according to parallel displacements in X and Y direction and according to yaw and pitch angular displacement, the computer computes, separately or according to other criteria, the relative position of the reference axis BA of the object relative to the primary reference beam R_p as well as values for corrections which are to be undertaken at predetermined assembly points of the object for elimination of a displacement requiring correction.

The terminals S_x, $S_{y,Sx'}$ and $S_{y'}$ and as well as the computer **4** with its data converter **3** are indicated schematically only in FIG. **1**, but are of course provided with the same intended purpose also in conjunction with the other figures.

The FIG. **2** by comparison with FIG. **1** shows a different relative position of the reference axis BA with respect to the primary reference beam R_p, which can have resulted through change in the position of the object in the measurement space for any reasons, for example, through operationally caused stresses of a machine forming the object. With the change in the position of the reference axis BA, the position of the position detectors **23** and **25** relative to the reference beam R_p and thereby the position of the respective point of incidence on the detector plane have also changed. The positional change in FIG. **2** is predominantly a change in the angular position. Of course, a pure parallel displacement could also be concerned, thus a uniform change in spacing of the reference axis BA with respect to the primary reference beam R_p, or a combination of both kinds of displacement. It is also evident that angular changes in the plane of the drawing of the FIG. 2 as well as also perpendicularly thereto, thus a yaw angular displacement as well as also a pitch angular displacement, have the consequence of a change in the position of the point of incidence A or A' on at least one of both the position detectors. On a positional change of a point of incidence and due to the thereby consequent change in the coordinates x and y or x' and y', corresponding changes also result in the signals S_x and S_y or $S_{x'}$ and $S_{y'}$ which the computer in the case of the distance of the position detectors **1** and **2** from the radiation source S being known is capable of processing into a corresponding statement in respect of the position of the reference axis BA in the measurement space and corresponding correction values.

The arrangement of the position detectors **23** and **25** according to FIGS. **1** and **2** one physically behind the other would presuppose that the front position detector **23** for the primary reference beam R_p is at least partially transparent. This is technically not to be realized simply at the present time. Therefore, in known devices according to the species as well as also in the device according to the invention according to FIGS. **3** and **5**, customary light-impermeable position detectors **23** and **25** are used in conjunction with the merely virtual arrangement, still to be explained in the following by reference to the FIG. **3**, of one of both the position detectors in the direction of projection of the primary reference beam R_p.

According to FIG. **3**, the position detector **25** is arranged only virtually behind the position detector **23** in direction of the primary reference beam R_p, thereagainst physically outside the direction of projection emanating from the beam transmitter S. The position detector **23** has remained physically in the aforenamed direction of projection and, as in the scheme discussed in the preceding, arranged by its detector plane substantially perpendicular to the primary reference beam R_p, when the reference axis BA lies parallelly to this.

The position detector **25** is disposed at the object laterally beside the primary reference beam R_p, while its detector plane stands perpendicularly on that of the position detector **23** and is rotated relative to the position according to FIG. **1** about an axis perpendicular to the plane of the drawing of the FIG. **3**. Before the reference beam R_p has reached the position detector **23**, it impinges on a beam splitter **22**, which branches off from it a partial beam $R_{p'}$, which impinges perpendicularly on the detector plane of the position detector **25**, when the reference axis BA lies parallelly to the reference beam R_p. The point of incidence A' of the reference beam $R_{p'}$ in a predetermined initial position of alignment corresponds in respect of its spacing from the reference point BP to the point of incidence of the reference beam R_p on the position detector **23** so that the same conditions are present functionally as for the scheme according to FIG. **1**.

Through the insertion of optical lenses **21** in front of the splitter mirror **22** and/or in front of the position detector **23** and/or in front of the position detector **25**, any desired virtual arrangement of the position detector **25** can be achieved in the device according to the invention in the direction of projection of the primary reference beam R emanating from the radiation source S, thus either in front of or behind the position detector **23**, for which three examples are indicated by dashed lines in FIG. **3**.

Through appropriate structuring of the lenses **21**, it is also possible to enlarge the detector planes seen from the radiation source S and thereby to obtain a measurement range matching.

In the case of the functional principles according to FIGS. **1** to **3**, the knowledge—needed for the computer—of the distance of the position detectors **23** and **25** from the radiation source S is obtained in any manner independently of the measuring device.

Thereagainst, the measurement principle, usable alternatively according to the invention and illustrated in FIG. 4, opens up the further possibility to obtain this knowledge by the same device, by which the parallel displacement and the yaw and pitch angular displacement are ascertainable. This is made possible according to FIG. 4 thereby, that a secondary reference beam R_s is emitted by the radiation source S still in addition to the primary reference beam R_p and at an acute angle hereto, wherein the angle and the direction of projection for both the reference beams are so chosen that both reference beams impinge on the detector plane of at least one of the position detectors 1 and 2 for all possible positions of the reference axis BA. It is evident that for a known angle α between both the reference beams, the respective spacing of both the points of incidence A_s and A_p or $A_{s'}$, and $A_{p'}$ in the one or other detector plane is a measure of the distance of the position detector 23 or 25 concerned from the radiation source S, thus the knowledge of this distance needed for the calculation can be obtained on the one hand and also changes in distance of the position detectors from the radiation source S are detectible on the other hand. Beyond that, the direction, which expresses itself in the co-ordinates x and y or x' and y' of each of both the points of incidence, of the spacing between the points of incidence in each detector plane also permits a statement about the angular position or the rotary angle of both the detectors rigidly coupled one with the other by way of the object—and thereby about the reference axis BP about the primary reference beam R_p and thus also the detection of changes in this angular position.

The FIG. 5 shows schematically a practical embodiment of the device according to the invention, which operates on the principle of the virtual position detector alignment with optical influencing of the effective detector spacing according to FIG. 3 and operable selectably also on the two-beam principle according to FIG. 4 and which distinguishes itself by particularly small dimensions and nevertheless acts like a device which by comparison with it displays substantially larger detectors at a very great spacing relative to their actual dimensions and accordingly has a great measuring range with great angular measurement sensitivity.

In the device according to FIG. 5, a radiation transmitter S emits a primary reference beam R_p and a secondary reference beam R_S. At the object end, the device displays a measurement part 20, which is rigidly fastenable at the object and into which both the reference beams R_p and R_s enter through a lens 21. In the measurement part 20, they impinge initially on the splitting mirror 22. This allows the reference beams R_p and R_s through rectilinearly to the first position detector 23, the detector plane of which is oriented substantially perpendicularly to the reference beam R_p.

The partial beams $R_{p'}$ and $R_{s'}$, which have been branched off from the incident reference beams R_p and R_s by the splitting mirror 22, are conducted to the second position detector 25, the detector plane of which lies in about the same plane as that of the first detector 23. To obtain a particularly large virtual spacing between the position detectors 23 and 25, the partial beams R_p and R_s are initially reflected by the splitting mirror 22 obliquely downwards in direction against the direction of incidence of the incident reference beams R_p and R_s and then once again at a customary deflecting mirror 24 in order geometrically prolonged to impinge only then on the position detector 25, the co-ordinate axes of which lie substantially parallelly to those of the position detector 23.

The lens 21 is so structured that the position detectors 23 and 25 seen from the radiation transmitter S come to appear as detectors 23' and 25', which are substantially enlarged compared with their actual dimensions on the one hand and arranged at substantially greater spacing one behind the other relative to the dimensions in the measurement part 22 on the other hand and onto which the reference beams R_p and R_s impinge directly in the direction of projection emanating from the radiation source S.

The individual components of the measurement part 20, i.e. the convergent optical system 21, the splitting mirror 22, the deflecting mirror 24 and the position detectors 23 and 25 are cemented together into a stable interference-proof compact optical glass system which in particular also excludes a condensation of water vapour at the optically active surfaces.

By the embodiment according to FIG. 5 and with dimensions in the order of magnitude of a cigarette carton or even smaller, the position of an object or of a fixed reference axis thereof relative to the reference beam R_p can be determined with greatest precision and positional changes relative to an initial position can be ascertained separately in respect of the following components:

a) parallel displacement in all directions,

b) pitch angular displacement,

c) yaw angular displacement and

d) rotary angular displacement.

Beyond that, the distance of the detectors from the radiation source S and a displacement with respect thereto is also ascertainable by this device.

Since position detectors in the simple embodiment according to FIG. 6 would in undesired manner supply electrical output signals intermixed in each detector plane in respect of both the points of incidence A_p and A_s, the radiation transmitter S on the use of such or similar detectors in the device according to FIG. 5 emits the reference beams R_p and R_s alternately in rapid sequence so that the co-ordinates of both the points of incidence arise one after the other in time and thereby separately as corresponding electrical signals.

The FIGS. 6a to 6c serve the explanation of the basic manner of effect of a form of construction of an analog biaxial photo-electronic semiconductor position detector usable in the device according to the invention.

The position detector according to FIGS. 6a to 6c displays a covering layer 30 of gold, a depletion zone 31 thereunder and a high-resistance substrate 32 again thereunder, wherein a current I_o is conducted to the gold covering layer 30 and contact strips 33 are arranged at the substrate laterally as well as at the top and bottom along the substantially square-substrate cross-section, by way of which contact strips the supplied current I_o flows away divided up into partial currents. The division of the current I_o is dependent on the point, at which a light beam impinges on the gold covering layer. In this illustrated form of construction, the supplied current I_o is divided up into four partial currents which flow away by way of the individual contact strips 33 and in respect of their magnitude depend on the spacing which the point of incidence of the light beam has from the centre. When the beam thus impinges exactly in the centre of the square gold covering layer congruent with the depletion zone and the substrate, the four partial currents of each equally great one among the other. The rectangular components of the spacing of an eccentric point of incidence of the light beam from the co-ordinate centre can be read off from a possible current difference at the contact strips 33 lying oppositely in pairs one with respect to the other.

Position detectors of the aforedescribed kind are known apart from other basically suitable forms of construction and obtainable in commerce.

What is claimed is:

1. Device for determining the distance of an object using substantially parallel focused reference beams of electromagnetic radiation directed thereto, comprising:

a) a radiation transmitter for emitting of a pair of substantially parallel focused reference beams of electromagnetic radiation at a predetermined acute angle relative to each other;

b) a position detecting unit which is fastenable to the object, said position detecting unit having first and second biaxial opto-electronic position detectors which are arranged at approximately the same height relative to said pair of reference beams in mutually parallel planes which are at different distances from the transmitter in a direction of emission of said pair of reference beams, and each of which emits electrical signals representative of mutually perpendicular, translational position coordinates, in magnitude and sign, of a point of incidence of each of said pair of reference beams on the respective position detector;

c) an electronic processing unit connected to each of said opto-electronic position detectors, and having means for computing the distance between the object and the transmitter from the electrical signals emitted by the position detectors and the angle between said pair of reference beams;

d) a splitting mirror arranged in a linear beam path of each of said pair of reference beams from the transmitter to the first opto-electronic position detector for splitting each of said reference beams, permitting a first portion of each of said reference beams to pass to the first opto-electronic position detector and diverting a second portion of each of said reference beams in a direction obliquely opposite to a direction of linear beam path, which is from said transmitter to said splitting mirror, to a deflecting mirror for deflecting the second portion of each of said reference beams to said second opto-electronic position detector along a longer path than that of the first portion of each of said reference beams between the splitting mirror and the first opto-electronic position detector.

2. The device according to claim 1, wherein the radiation transmitter has means for emitting a second reference beam toward said splitting mirror, said detecting mirror and said enlarging optical system at an acute angle relative to said first reference beam, the position detectors being in the path of said first and second said reference beams.

* * * * *

(12) **United States Patent**
Hoelzl et al.

(10) **Patent No.: US 6,476,914 B1**
(45) **Date of Patent: Nov. 5, 2002**

Evidence appendix 5

(54) **PROCESS AND DEVICE FOR ASCERTAINING WHETHER TWO SUCCESSIVE SHAFTS ARE IN ALIGNMENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/315,157**

(22) Filed: **May 20, 1999**

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**[7] **G01B 11/00**

(52) **U.S. Cl.** **356/400**; 356/150; 250/208.2; 250/559.3; 250/559.39

(58) **Field of Search** 356/400, 399, 356/150, 153, 154, 155, 141.1, 141.2; 250/578.1, 559.37, 559.39, 559.3, 208.2

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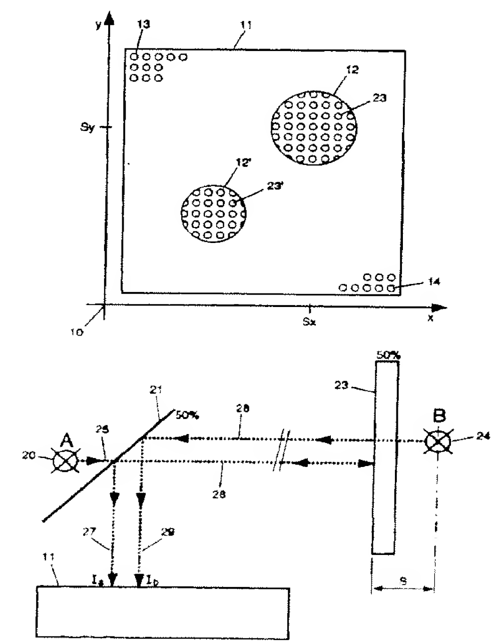
(57) **ABSTRACT**

The effectiveness of a method for checking for exact alignment of two successive shafts, axles or the like is improved by the fact the no measures with respect to linearization or temperature compensation are necessary any longer by using a light-sensitive array as the light-sensitive sensor. The effects of outside light and reflections can be suppressed. The cross section and the quality of a detected laser beam can be checked especially by visual inspection. Production of the corresponding device for executing this process is facilitated. By using matched beam splitters and reflectors as well as light sources of different colors the number of optoelectronic sensors necessary can be significantly reduced.

13 Claims, 5 Drawing Sheets



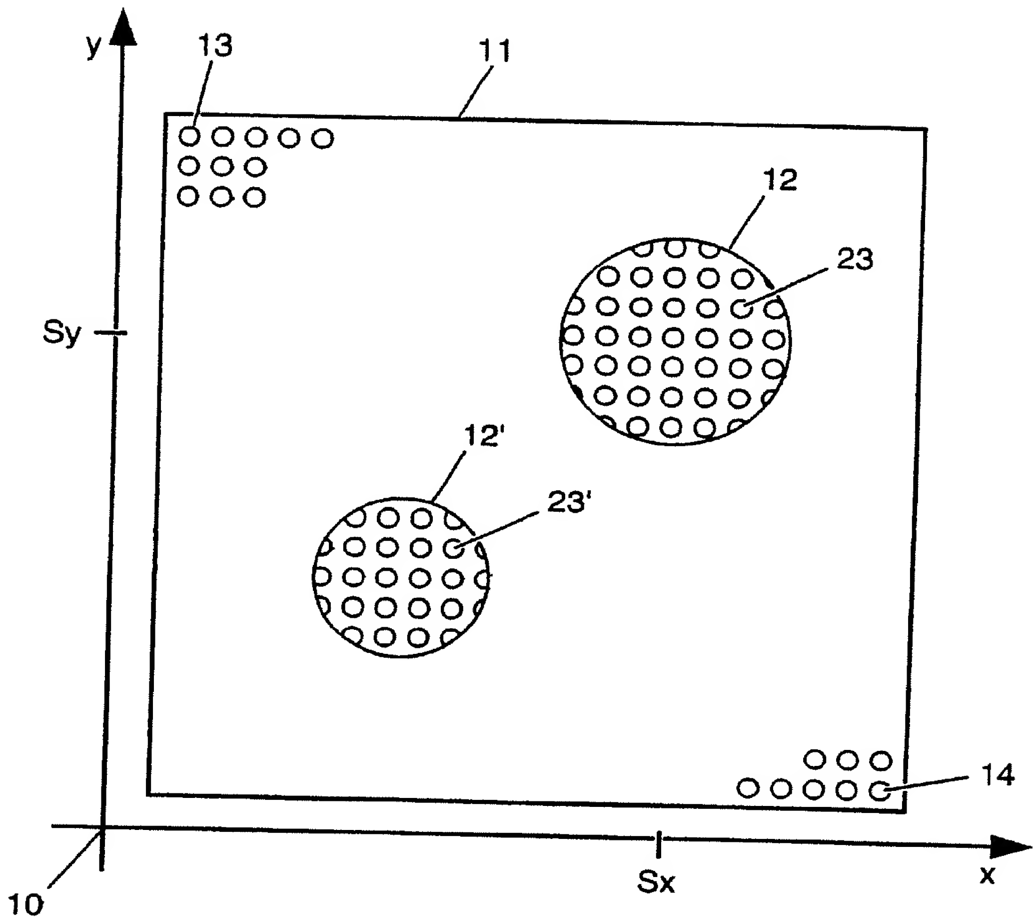


Fig. 1

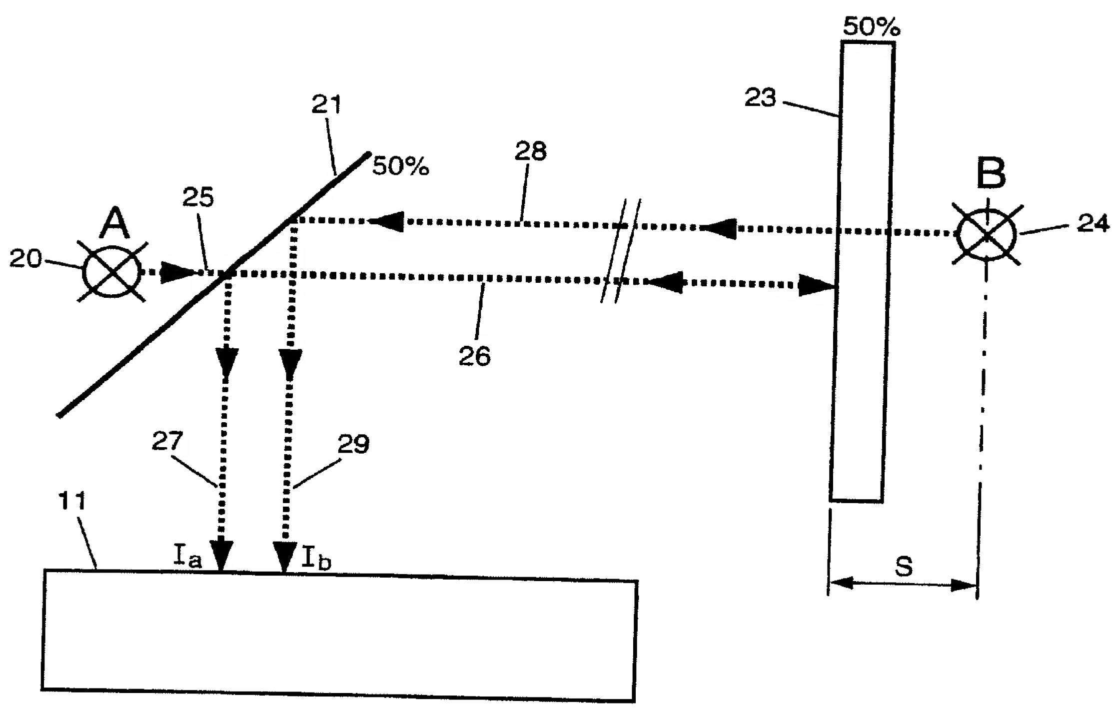


Fig. 2

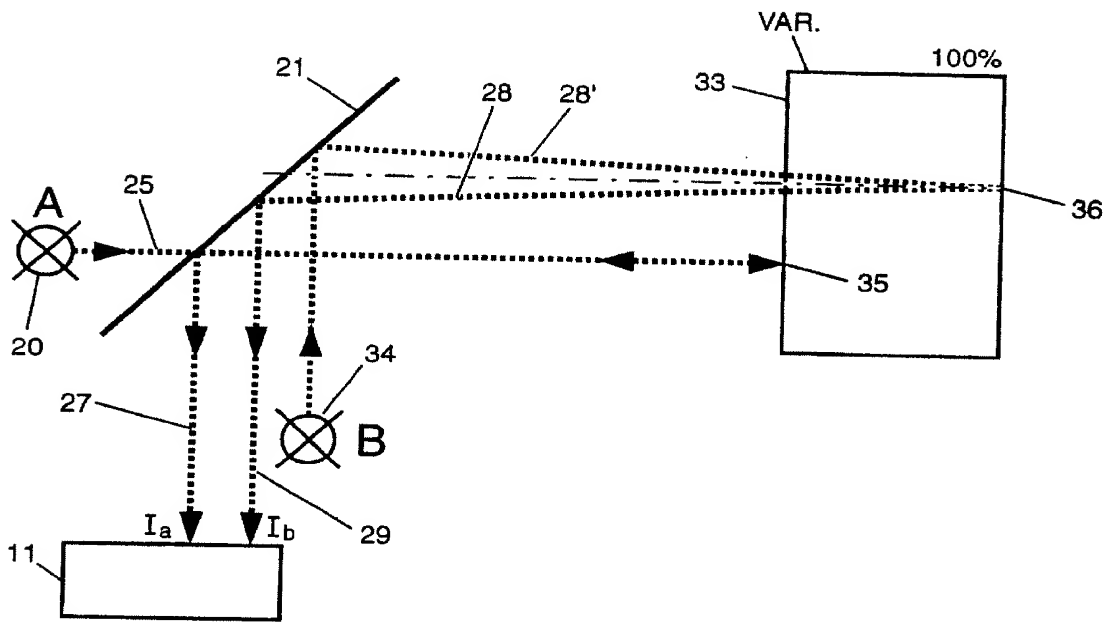


Fig. 3

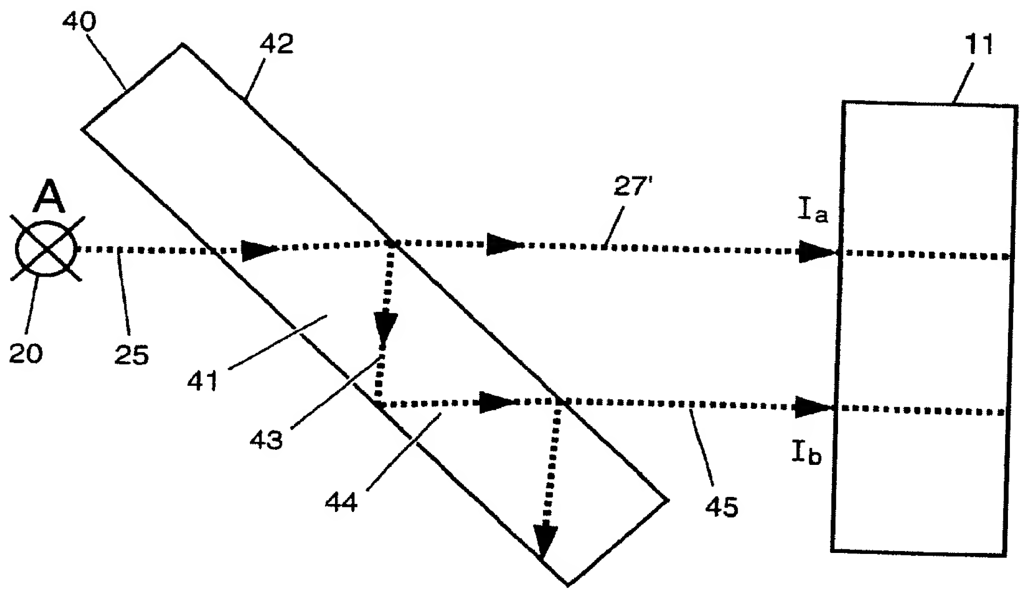


Fig. 4

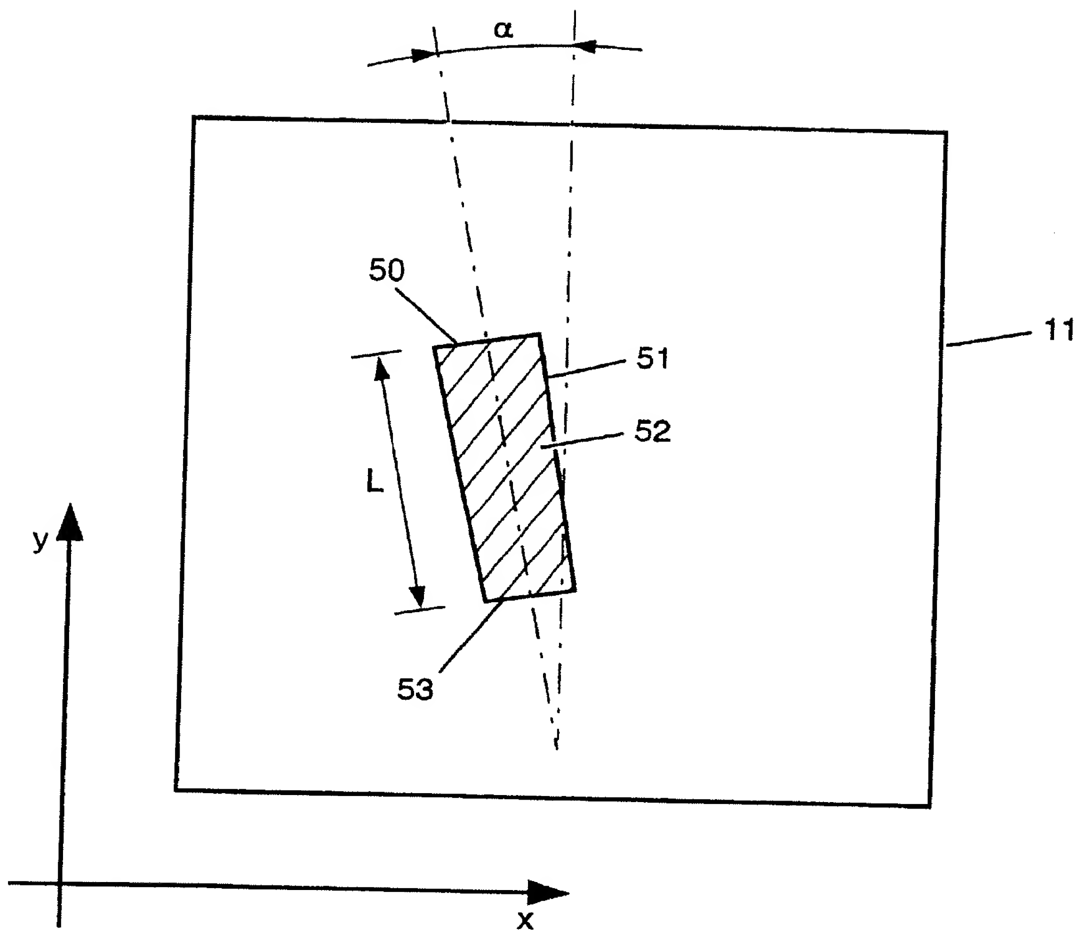


Fig. 5

PROCESS AND DEVICE FOR ASCERTAINING WHETHER TWO SUCCESSIVE SHAFTS ARE IN ALIGNMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a process and device for ascertaining whether two successive shafts are in alignment.

2. Description of the Related Art

Processes for exactly aligning two successive shafts to one another were carried out in the past, primarily with purely mechanical measurement means. Typical examples of activities of this type were alignment of electric motors on directly coupled pumps or comparable assemblies. Since it became possible later to replace the mechanical measurement pointers provided for in these processes by light pointers and the pertinent mechanical sensors by electronic ones, a significant facilitation and improvement in the execution of the pertinent measurement tasks were established. Simultaneous use of microprocessors in this connection, and especially for the calibration measurement to then be carried out on the corresponding machines or devices turned out to be extremely helpful.

SUMMARY OF THE INVENTION

Electronic sensors used in the form of special photoelements provided with flat resistance elements, either as selected components, or to provide a linearization process for them. In this way inaccuracies and nonlinearities relating to the location of an incident light beam, and a recordable output signal of the sensor may be kept relatively small. Furthermore, the corresponding nonlinearities were dependent on temperature to a certain extent.

The object of this invention is to largely eliminate these defects of an otherwise extremely useful older invention, especially nonlinearities, and to reduce the temperature dependency which may be present in the optical sensor/sensors to be provided, and at the same time to significantly increase the precision, i.e. the repeatability and resolution of this sensor, to a large degree.

Another object of the invention is to significantly reduce the number of optical and/or optoelectronic components to be used or to design them more economically.

These object are achieved by devising a process which is used to ascertain whether two successive shafts are in alignment with respect to their center axes or are offset against one another at an angle and/or at a distance. By means of several measurement pointers and the pertinent reference elements, a plurality of geometrical measured values can be generated via several measurement angular positions of the shafts which correspond to one another from shaft to shaft, two measurement values being independent of one another, and the measured values having a functional dependency at least on distance and angular offset (especially skewness) of the shafts. As the measurement pointer, at least one light beam in the form of a light bundle of low divergence, especially in the form of laser beam, may be used, and the light beam is oriented such that it is incident on at least one reference element in the form of an optoelectronic array with a plurality of pixels, especially a flat optoelectronic sensor which acts as a CCD (charge coupled device) and in doing so, illuminates and activates part of all the pixels of the array. The positions or coordinate values of the illuminated and activated pixels of the array are electronically determined individually, and with the aid of an electronic computer, at least one characteristic value is determined from the ascertained positions or the coordinate values which describes the location of the incident light spot on the optoelectronic array with respect to one or more coordinates.

For purposes of determining at least one characteristic value in accordance with the invention, preferably one or more, especially arithmetic averages, are computed which indicate the middle position of the light spot with respect to one or more stipulated coordinates.

In a roughly comparable manner, at least one characteristic value can also be determined by determining the focus of the light spot incident on the optoelectronic array. This focus determination relates to linear or flat arrangements of the indicated optoelectronic array. Since the light spot has no mass, it goes without saying that when the indicated focus is formed, light intensities are assumed. The light intensities can obey a continuous distribution here. But they can also be assigned to one of two intensity states, specifically to "on/bright" or alteratively "off/dark".

Furthermore, the process as claimed in the invention advantageously uses a computer and a pertinent program by which in addition to computing one or more averages the pertinent quantities, "scattering" or "variance" are determined. The shape of the light spot can be checked by this measure. This is based on the fact that an irregularly shaped light spot will produce other values for the indicated quantities as a light beam which is incident is regularly shaped on the optoelectronic array. In a comparable manner, if feasible, higher statistical moments can be used for evaluation and assessment of the quality of an incident light beam.

Since an incident light beam typically does not have a constant intensity over its cross section, but generally has an intensity peak in the vicinity of its axis, it is advantageous to define an edging cross sectional outline for this light beam such that before acquiring the signal, a threshold intensity is set so that activated pixels of an optoelectronic array in which the incident light beam has a local intensity greater than the aforementioned threshold intensity are considered. Therefore, this is especially advantageous because the corresponding component object can be achieved by using simple hardware in the form of a comparator. The same object can also be achieved by a suitable computer software combination, but the aforementioned approach is much more efficient and thus, economical. The required capacity of a computer which must be provided anyway, can be kept low by further processing only those pixels which can be assigned to one edge or transition between one intensity range with a first intensity value and another intensity range with a second intensity value.

To check the intensity and/or the cross sectional shape of the incident light beam, it is a good idea to check the number of activated pixels above or below stipulated boundary values. In this way, it becomes apparent whether an incident light beam is either too small or, for example, is on the edge areas of an illuminated optoelectronic array.

If enough computer time is available, it is also advantageous to supply a light spot (or its edges, as was mentioned above) to be recorded on an optoelectronic array for more extensive pattern recognition. Only when its shape recorded at the time corresponds to a stipulated criterion does optionally further evaluation take place, i.e. the determined characteristics are further used in a following computation step of a program assigned to the process in accordance with the present invention.

In another embodiment of the process in accordance with the present invention the process includes consists in another evaluation phase of recognition and computational elimination of the light portions which can be attributed to undesirable optical reflections. For this reason, in the conventional manner, methods of integral transformation, deconvolution operations and similar computer methods, especially based on the so-call Fast Fourier Transform, can be used.

In another embodiment of the invention, the process is the reverse, i.e. optical reflections are caused in a controlled manner and are used for evaluation by measurement. In this connection, it is advantageous for the provided sensor to be able to discriminate individual illuminated areas from one another and to parameterize them, i.e. to deliver the parameters for a plurality of individual objects relevant to measurement engineering. It should be remembered that to date, all devices used in this connection have been able to determine essentially only two parameters for incident light, specifically the focus of the incident light in one x-axis and in a y-axis orthogonal thereto.

Especially prompt availability of these characteristics is enabled by using the aforementioned discrimination of cases "on/bright" and "off/dark" for the light intensity at the site of an individual pixel of an optoelectronic array; is also possible for more accurate analyses, if they are desired or necessary, of the locally present illumination intensity of the incident light beam to be determined for an activated pixel and to be made available as a digitized quantity for further computation processes. This approach, specifically the interconnection, for example of a CCD sensor and an analog-digital converter (ADC), is known.

Regardless of whether the latter approach is used or not, in accordance with the present invention, the location and/or the cross section (or the intensity properties over the cross section) of at least one, but preferably several light beams recorded by the optoelectronic array can be completely displayed in an extremely simple manner on a downstream display. By means of this immediate visual control possibility, a user of the process in accordance with the present invention can be immediately informed whether the number and arrangement of incident light beams of correct size, shape and location appear.

To make the process in accordance with the present invention feasible, there is a corresponding device which can have a so-called CCD sensor as an especially economical basic component. In one qualitatively improved embodiment, a so-called CMOS image sensor is used. To further improve the optoelectronic signal acquisition, it can also be feasible to make available an auxiliary device which comprises a modulation or multiplexing device using conventional art, with which the light beam can be varied in its intensity or in its beam direction, especially can be turned on and off in pulses. In particular, LCD-based modulation means are advantageous for this purpose. They can also be used to provide the light beam with a variable cross section. In this way, it is possible to even better assess the quality of the light beam incident on the optoelectronic array or to deliver it to especially high quality pattern recognition in order to achieve especially accurate determination of the aforementioned characteristics.

The invention is explained below using the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the geometrical location and distribution of light intensities of at least one light spot

FIG. 2 shows the beam path relating to generation and detection of two light spots,

FIG. 3 shows another beam path relating to generation and detection of two light spots

FIG. 4 shows another beam path for generating two light spots, but with only one real light source

FIG. 5 shows the positioning of one light spot of elongated or asymmetrical shape.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows how one or more light spots **12**, **12'** which activate individual pixels **23**, **23'** of the array are generated by a light beam on an optoelectronic array **11**. In subsequent readout of the array **11** the positions of the illuminated pixels **23**, **23'** (and thus also the nonilluminated pixels (**13**, **14**) are determined. These positions can be determined relative to a Cartesian coordinate system which is provided permanently on the array **11** with x-axis and y-axis which intersect at the origin **10**. The technique of read-out of linear or flat optoelectronic arrays is examined hereinbelow. Determination of the characteristics Sx and Sy by which the location of the first light spot **12** is specified very accurately takes place by determining either (optical) focal coordinates for the focus S or other averages in the x-direction according to the aforementioned description by summation of the x-coordinates of the illuminated individual pixels **23**. The reference symbol Sx designates one such characteristic for the x-coordinate.

In the same way and independent of the determination of the corresponding characteristic which was done for the x-coordinate, analogous one such characteristic is computed for the y-coordinate. The reference symbol Sy designates one such characteristic for the y-coordinate. Determination of other statistical quantities which can be assigned to the illuminated pixels preferably corresponds to conventional computer methods and need not be detailed here.

In a comparable way, the coordinates of the focus for the light spot **12'** which can be characterized, for example, by lower light intensity, are determined.

Let it be established that before determining the indicated focus coordinates, automatic assignment of edges of one or more light spots takes place so that the focus determination can be assigned explicitly to the individual (and usually, variously bright or variously shaped) illuminated areas of the array or sensor which is used. The corresponding computational methods are known.

Although the indicated computations of averages or focus are also known, their application to the present invention yields a special advantage for the proposed process as described in per the following analysis.

In a light spot with a diameter of roughly 1 mm, 10000 pixels can be illuminated and are then, included in the computation of the average or focus. Since the distances of the pixels **23** are only a few microns using current technology, after completion of averaging, characteristics are formed which purely arithmetically have a resolution in the nanometer range. This resolution when compared to previous approaches, is several orders of magnitude finer, therefore, more favorable. At the same time, as a result of the process of production of the optoelectronic arrays, almost no linearization of the output signal is necessary any more. In addition, the determined characteristics Sx and Sy are only slightly dependent on temperature. Thus, the invention enables acquisition of measured values which leads to significantly more accurate end results in the application of the process given, for example, in the German reference DE3911307.

In addition, the acquisition of individual, different illuminated areas (light spots) on one embodiment of the sensor is shown in FIGS. 2 to 5.

FIG. 2 shows how an optoelectronic array 11 is illuminated at the same time by two light sources so that the illuminated areas Ia and Ib can be supplied separately from one another to be evaluated using measurement engineering. It is especially advantageous, for the light emitting devices A and B (more briefly called light sources, reference numbers 20 and 24) to emit light of different colors, i.e. wavelengths (or wave mixtures). In this case the, sensor (array 11) is sensitive to several colors, such as those used in so-called digital cameras. The array 11 is spaced a fixed distance relative to the light source 20 and to a partially transparent reflector 21. At a variable distance and with a variable orientation to the light source A, there is a combination consisting of the light source B (reference number 24) and a partially transparent reflector 23, the basic arrangement of the light source and sensors for the alignment instruments provided here being known and not further explained to avoid length. Advantageously, therefore the light source 24 is at a fixed distance to the partially transparent reflector 23, with a distance "s" as large as possible. The reflector 23 can be not only partially transparent, but can also have additional color filter action so that for example, it reflects strongly for green light and has an acceptable degree of transmission for red light. In this case, it is provided that the light source (A) (for example a semiconductor or a focussing light emitting diode) shows, for example green, while conversely, the light source B shows red or infrared, for example. A light beam 25 emerging from the light source 20 is therefore, attenuated first by the partially transparent reflector 21 and is incident on the front reflecting plane of the reflector 23. It returns attenuated as a reflected light beam 26, is again reflected on the reflector 21, but in the opposite direction, and is attenuated, and as light beam 27 generates the illuminated areas Ia on the array 11. This area, as a result of its green color, can be explicitly identified (if it cannot be recognized based on its location) as belonging to the light source 20. Depending on the position and orientation of the light source 24 and the reflector 23, the location of the impact of the light beam 27 on the array 27 varies. This makes available, a first measured quantity with which both the relative orientation of the combination 23, 24 with respect to 11, 20, 21 can be computed. Also information for calibration of pertinent objects or machines on which these combinations are temporarily attached for purposes of alignment can be computed. At the same time the light, source 24 with, for example red light, generates a directional and likewise attenuated light beam 28 which after reflection on the partially transparent reflector 21, is incident on the array 11 as the light beam 29 in attenuated form in the illuminated area Ib. This area can also be explicitly identified based on its different color. Thus, a second measured quantity is available to be able to perform the aforementioned measurement task.

Further processing of the indicated first and second measured quantities proceeds preferably using known methods. They are based, for the most part, on determining measurement quantities which vary sinusoidally over a mechanical angle of rotation, according to amplitude and phase and also optionally, the direction of rotation. The especially accurate determination of these quantities uses various methods of compensation calculation.

Similar assumptions apply to the arrangement shown in FIG. 3 so that its description can be kept brief, especially with reference to the aforementioned application document.

Similar to FIG. 2, the embodiment of FIG. 3 includes there are two preferably different light sources 20, 34, at this point the light sources 20, 34 and the partially transparent reflector 21 and the pixel array 11 being spaced a fixed distance among one another. Both light sources 30, 34 cause, similarly to as is shown in FIG. 2, two illuminated areas Ia and Ib which have different colors and/or different locations. This arrangement has the advantage that all active components are arranged in a concentrated manner and a measurement instrument component which can be varied in location and orientation can consist of only one special reflector 33. The reflector 33 preferably has a roughly 100% reflecting back surface 36 which is spaced relatively far from the front side 35 (roughly 5 to 50 mm). In addition, there is partially transparent mirroring on its front side 35 which can also have a color filter action. When the orientation of the reflector 33 varies with respect to the reflector 21, with consideration of the beams 27, 28, 28' and 29, different positions of the illuminated areas Ia and Ib arise which can likewise, be evaluated by measurement engineering. This approach, as well as the approach shown in FIG. 2, when compared to the prior art, saves a second two-dimensionally acting optoelectronic detector element which is otherwise necessary.

FIG. 4 shows another approach where there is only a single light-emitting device 20 for sending a light beam of narrow diameter 25. The light source 20 and the combination of a detection array 11 and a plane-parallel transparent plate 40 which is mirrored on both sides and partially transparent, are spaced at variable distances and can be oriented to one another according to the measurement task to be performed. The detection array 11 and the plate 40 are spaced (and thus oriented) at a fixed distance and with high precision to one another. The plate is relatively thick and is made of "Zerodur" to achieve a high thermal stability. The distance of the front plane 41 from the back plane 42 of the plate is roughly 5 to 50 mm. When the angle of incidence of the light beam 25 on the plate 40 varies slightly, measurably different distance changes of the illuminated areas Ia and Ib arise on the array 11 since it can provide an extraordinarily high local resolution by means of methods of statistics and feature extraction.

As shown in FIG. 4, the light beam 25 which is incident on a front plane 41 at a relative angle of roughly, for example, 45° to the surface normal is partially reflected and there, partially refracted into the optically denser medium of the plate, to then be incident on the array 11 after partially passing through the back plane 42 as beam 27 with parallel offset.

The remainder of the light beam which has been transmitted on the plane 42 is fractionally reflected and as the beam 43, it is incident on the front plane 41, as shown. Partial reflection takes place again so that a beam 44 which is already clearly attenuated after further attenuation, is incident on the array 11 through the back plane 42 as the beam 45, which depending on the thickness of the plate 42 is positioned at a relatively great distance to the area Ia. This distance changes slightly, but can be measured very accurately when the angle of incidence of the beam 25 varies. The positions of the areas Ia and Ib conversely, change directly with the variation of the incidence site of the beam 25 on the plate 40, instead of a plate 40 there can be identical mirror surfaces spaced in parallel which do the same thing, with temperature-independent and position-independent parallel alignment. However, such arrangement is either less accurate or which can be made available only with greater cost. Furthermore, the array 11 and the plate 40 for improv-

ing the required stability can be located at a more acute angle or parallel to one another.

In another embodiment of the invention, it is shown in FIG. 5 how with the aid of pixel-oriented light sensors, other measurement engineering possibilities which had not previously been used can be made available. If in conjunction with the underlying measurement object, a stipulated light beam is shaped or a light source imaged such that an elongated or asymmetrical light spot **50** arises on the array **11**, in addition to the location of the focus **52** relative to an x-y coordinate system, the angular orientation of the light spot **50** to the array **11** can also be determined. Thus, an angle of rotation alpha ("roll angle") of the emitting light source can be indicated relative to the x-axis of the array **11**. This will be used, for example, for determining the coupling errors in coupled shafts, axles and the like. The mathematical methods for determining the main direction of the light spot **50** with respect to its focus **52** and relative to the x-axis of the array **11** can thus be regarded as known.

In addition, using the side ratios of, for example, the short side **53** and the long side **51** of the light spot, a conclusion can be drawn about the imaging quality so that when the imaging ratios are insufficient, taking of the measurement can be automatically refused or at least criticized. If the side ratio is recognized as acceptable, based on the length of the side **51** under certain circumstances, a conclusion can be drawn regarding how far the array is located from the emitting light source. This process is more accurate than if only the diameter of a circular light spot is measured. In addition, measures must be taken for at least changing portions of the light spot in the manner of a projection process depending on distance. It is therefore recommended that for this special additional method of measuring the rotary position and distance, either projective imaging of light emitting diodes or laser diodes be done or an existing laser beam with the corresponding beam shaping be modified.

What is claimed is:

1. A method for ascertaining alignment of two successive shafts comprising the steps of:

providing at least one measurement pointer for generating a light beam having low divergence;

providing at least one reference element including an optoelectronic array with a plurality of pixels;

orienting said light beam from said measurement pointer such that said light beam is incident on said at least one reference element to illuminate and activate at least some of said plurality pixels of said optoelectronic array;

determining coordinate values of illuminated and activated pixels of said optoelectronic array to determine the position of said illuminated and activated pixels which correspond to a light spot on said optoelectronic array;

measuring the quantity of at least one of light scattering and variance to determine a shape of the light spot incident on said optoelectronic array; and

generating a plurality of geometrical measured values corresponding to an alignment characteristic including at least one of distance and angular offset between said two shafts based on said coordinate values of the illuminated and activated pixels forming the light spot, wherein said alignment characteristic is determined based on a computed arithmetic average which indicates a middle position of said light spot.

2. Method of claim 1, wherein said alignment characteristic is determined by an electronic computer.

3. Method of claim 2, wherein said measurement pointer is a laser and said optoelectronic array is a flat charge coupled device (CCD).

4. Method of claim 1, wherein an alignment characteristic is further determined by calculating an intensity of light incident on said optoelectronic array.

5. Method of claim 1, further comprising the step of providing a threshold intensity which must be exceeded by an intensity of said incident light beam in order to activate each of said plurality of pixels of said optoelectronic array.

6. Method of claim 5, wherein at least one of intensity and a shape of said incident light beam is determined by monitoring at least one of the number of activated pixels and the number of nonactivated pixels.

7. Method of claim 1, further comprising the step of comparing said shape of said light spot on said optoelectronic array to a stipulated shape criterion and storing said shape of said light spot into a memory device for an additional processing step.

8. Method of claim 7, wherein said additional processing step comprises the steps of determining light portions which can be attributed to optical reflections and computationally eliminating said light portions which can be attributed to optical reflections.

9. Method of claim 1, further comprising the step of determining an illumination intensity of said incident light beam on an activated pixel and providing a digitized signal corresponding to said illumination intensity.

10. Method of claim 1, further comprising the step of displaying at least one of a location and a shape of a light spot incident on said optoelectronic array on a display screen.

11. Device for ascertaining alignment of two successive shafts comprising:

a first and a second light source for generating light beams of narrow cross section;

a first and a second optical element, each of said first and second optical elements being partially transparent and partially reflective;

an optoelectronic array for detecting said light beams;

wherein said first light source, said first optical element and said optoelectronic array are oriented and spaced in a fixed position relative to one another, said first optical element being substantially flat and aligned in a manner that said light beams are at least one of incident and reflected at an angle of incidence of substantially 45° relative to a surface normal; and

wherein said second light source and said second optical element are oriented in a fixed position relative to one another and are spaced by a predetermined distance in a manner that said light beams generate separable illumination areas which are distinguishable from one another on said optoelectronic array.

12. Device of claim 11, wherein said first light source generates a light beam having a different spectral composition than a light beam generated by said second light source.

13. Device for ascertaining alignment of two successive shafts comprising:

a light source for generating a primary light beam of narrow cross section;

a pixel-based optoelectronic sensor; and

an optical plate which is partially transparent and partially reflective having a first surface and a second surface which are substantially parallel to each other, said optical plate being oriented and spaced in a fixed position relative to said optoelectronic sensor and being adapted to divide said primary light beam which is incident at an angle to said optical plate into at least one first and one second secondary light beam, each of

which illuminates a first and a second area of said optoelectronic sensor respectively;

wherein a distance between said first and said second area of said optoelectronic sensor illuminated by said at least one first and one second secondary light beam is determined by said angle of incidence of said primary light beam on said first surface.

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